Interreg CENTRAL EUROPE

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Drive2Transform

TRANSFORMATION READINESS MODEL

Annex 1 Reference Model

Version 1

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Annex 1 Reference model

The below presented reference model for each of the four thematic areas gives an overview of main products (for connectivity and platform economy also services), critical production technologies and critical competencies.

Inhaltsverzeichnis

1. Electricifation

1.1. Products

- Powertrain Components: Electric Motors, Battery Packs, Power Electronics (Inverters, Converters), Onboard Chargers, Motor Controllers, Drive Units
- Battery System Components: Battery Cells, Battery Management Systems (BMS), Battery Thermal, Management Systems, Battery Modules, Battery Pack Enclosures
- Charging Components: Charging Ports, Charging Cables, DC Fast Chargers, Wireless Charging Systems, Home Charging Stations
- Control Systems: Vehicle Control Units (VCU), Autonomous Driving Systems, Advanced Driver, Assistance Systems (ADAS), Telematics Units, Human-Machine Interface (HMI) Systems
- Cooling and Heating Systems: Thermal Management Systems, Coolant Pumps, Heating, Ventilation, and Air Conditioning (HVAC) Systems, Heat Exchangers
- Transmission Components: Single-Speed Transmissions, Two-Speed Transmissions, Differentials
- Interior Components: Infotainment Systems, Digital Instrument Clusters, Seats and Upholstery, Interior Lighting, Dashboards
- Exterior Components: Body Panels, Lighting Systems (LED Headlights, Taillights), Windshields, Mirrors, Wipers
- Chassis and Suspension Components: Suspension Systems, Steering Systems, Braking Systems, Axles
- Safety Systems: Airbags, Crumple Zones, Reinforced Passenger Cells, Collision Detection Systems
- Wiring and Connectivity: High Voltage Wiring, Low Voltage Wiring, Connector Systems, Sensors
- Software Components: Battery Management Software, Motor Control Software, Vehicle Control Software, Navigation Systems, Over-the-Air (OTA) Update Systems
- Energy Recovery Systems: Regenerative Braking Systems, Energy Harvesting Systems
- Miscellaneous Components: Tires, Wheels, Fasteners, Insulation Materials

1.2. Critical production technologies

- Battery Production Technologies
  - Lithium-Ion Battery Manufacturing
    - Electrode Production: Coating, drying, calendaring, and slitting of electrodes.
    - Cell Assembly: Stacking or winding of electrodes, separator insertion, electrolyte filling.
    - Formation and Aging: Charging and discharging cycles to stabilize the battery.
    - Battery Module and Pack Assembly: Integrating cells into modules and packs, including welding and thermal management integration.
  - Solid-State Battery Manufacturing
    - Thin Film Deposition: Techniques such as sputtering and chemical vapor deposition (CVD) for creating solid electrolytes.
    - Lithium Metal Anode Processing: Specialized handling and assembly techniques.
- Electric Motor Production Technologies
  - Winding and Assembly
    - Wire Winding Machines: Automated machines for precise winding of motor coils.
    - Stator and Rotor Assembly: Precision assembly techniques to integrate windings into the motor structure.
    - Magnet Insertion: Automated insertion and bonding of permanent magnets into rotors.
  - Casting and Machining
    - High-Pressure Die Casting: For producing lightweight and complex aluminum motor housings.
    - CNC Machining: For precision manufacturing of motor components such as shafts and housings.

- Power Electronics Production Technologies
  - PCB Manufacturing
    - Surface Mount Technology (SMT): Automated placement and soldering of electronic components on printed circuit boards (PCBs).
    - Wave Soldering and Reflow Soldering: Techniques for soldering through-hole and surface-mounted components.
- Lightweight Materials and Structural Components
  - Composite Materials Manufacturing
    - Carbon Fiber Layup and Curing: Manual or automated layup of carbon fiber prepregs, followed by autoclave curing.
    - Resin Transfer Molding (RTM): Injecting resin into a mold containing a fiber preform.
  - Aluminum and High-Strength Steel Fabrication
    - Sheet Metal Stamping: Forming aluminum and high-strength steel sheets into body panels and structural components.
    - Laser Cutting and Welding: Precision cutting and welding for creating complex structures.
- Thermal Management System Production
  - Heat Exchanger Manufacturing
    - Brazing and Soldering: Techniques for assembling heat exchangers such as radiators and battery cooling plates.
    - Injection Molding: For producing plastic components used in thermal management systems.
- Advanced Manufacturing and Assembly Technologies
  - Additive Manufacturing (3D Printing)
    - Prototyping and Small Batch Production: Using 3D printing to create prototypes and low-volume production parts.
    - Metal Additive Manufacturing: Techniques like selective laser melting (SLM) for producing complex metal parts.
  - Robotics and Automation
    - Automated Assembly Lines: Utilizing robots for tasks such as welding, painting, and assembly to increase precision and efficiency.
    - Collaborative Robots (Cobots): Working alongside human operators to perform repetitive or dangerous tasks.
- Quality Control and Testing
  - Non-Destructive Testing (NDT)
    - X-Ray and Ultrasonic Testing: Inspecting internal structures without damaging components.
    - Thermography: Using thermal cameras to detect defects in electrical components.
  - Environmental and Stress Testing
    - Temperature and Humidity Chambers: Simulating extreme conditions to test the durability of components.
    - Vibration and Shock Testing: Ensuring components can withstand operational stresses.
- Software and Digital Technologies
  - Computer-Aided Design (CAD)
    - 3D Modeling and Simulation: Designing and simulating components before production.
  - Digital Twin Technology
    - Virtual Prototyping and Testing: Creating digital replicas of physical components for testing and optimization.

1.3. Critical competencies

- Battery Technology

  - Battery Cell Design and Manufacturing: Expertise in design and producing lithium-ion cells or solid-state batteries.
  - Battery Management Systems (BMS): Knowledge of BMS design and integration for optimal battery performance, monitoring and safety.
  - Energy Storage Solutions: Developing efficient and reliable energy storage systems for electric vehicles.
- Electric Powertrain
  - Electric Motor Design and Manufacturing: Skills to design and produce electric motors for various vehicle types.
  - Power Electronics: Skills for developing inverters, converters, and other electronics for efficient power management.
  - Drive Systems Integration: Skills to integrate motors, controllers, and transmissions for seamless power delivery.
- Vehicle Integration and Assembly
  - Vehicle Platform Design: Understanding of vehicle architectures optimized for electric powertrains and battery systems.
  - Assembly Line Expertise: Proficiency in establishing and optimizing production lines for electric vehicle assembly with high efficiency and quality control.
  - Integration of Advanced Systems: Ability to integrate complex systems like regenerative braking and thermal management.
- Advanced Materials and Lightweight Structures
  - Material Science: Knowledge of lightweight materials such as carbon fibre composites, high-strength alloys, and advanced polymers.
  - Structural Design: Skills in designing vehicle structures that optimize weight, safety, and aerodynamics.
  - Manufacturing Processes: Expertise in advanced manufacturing techniques like casting, forging, machining, and additive manufacturing for complex components.
- Safety and Regulatory Compliance
  - Safety Engineering: Understanding and implementation of safety standards specific to electric vehicles.
  - Regulatory Knowledge: Staying updated with global regulations related to electric vehicle components and systems.
  - Testing and Validation: Experience in conducting rigorous testing and validation to ensure compliance with safety and performance standards.
- Software and Connectivity
  - Embedded Systems: Ability to develop embedded software for vehicle control units (VCUs), BMS, and other electric vehicle systems.
  - Connectivity Solutions: Integrating IoT technologies for vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication.
  - Cybersecurity: Implementing cybersecurity measures to protect vehicle data and systems from cyber threats.
- Advanced Manufacturing Capabilities
  - Precision Engineering: Utilizing advanced manufacturing techniques for high-precision components.
  - Lean Manufacturing: Implementing efficient production processes to reduce waste and optimize throughput.
  - Automation and Robotics: Integrating automated systems for consistent quality and increased production efficiency.
- Quality Control and Assurance
  - ISO Standards Compliance: Meeting international quality standards.
  - Testing and Validation: Conducting rigorous testing for reliability, durability, and safety.
  - Supplier Quality Management: Implementing processes to ensure consistent quality across the supply chain.

- Regulatory and Compliance Knowledge
  - Safety Standards: Understanding and complying with automotive safety regulations.
  - Environmental Regulations: Adhering to regulations governing materials and manufacturing processes (e.g., REACH, RoHS).
  - Cybersecurity Standards: Implementing measures to protect electronic components from cyber threats.
- Environmental and Sustainability Practices
  - Green Manufacturing: Implementing eco-friendly manufacturing processes and reducing environmental impact.
  - Recycling and Waste Management: Developing strategies for recycling materials and reducing waste.
  - Lifecycle Assessment: Analysing environmental impacts throughout the product lifecycle.

2. Automation

2.1. Products

- Sensing Components: Lidar Sensors, Radar Sensors, Ultrasonic Sensors, Cameras (Surround View, Front, Rear, Side), Infrared Sensors
- Computing and Processing Units: Central Processing Units (CPUs), Graphics Processing Units (GPUs), Neural Network Accelerators, Field-Programmable Gate Arrays (FPGAs), Microcontrollers
- Control Systems: Autonomous Vehicle Control Units (AVCU), Vehicle Control Units (VCU), Electronic Control Units (ECU), Drive-by-Wire Systems, Steer-by-Wire Systems, Brake-by-Wire Systems
- Software and Algorithms: Sensor Fusion Software, Path Planning Algorithms, Machine Learning Models, Object Recognition Software, Localization and Mapping Software, Motion Control Algorithms
- Communication Systems: Vehicle-to-Vehicle (V2V) Communication Systems, Vehicle-to-Infrastructure (V2I) Communication Systems, Vehicle-to-Everything (V2X) Communication Systems, Telematics Units, 5G Modules
- Human-Machine Interface (HMI): Digital Instrument Clusters, Touchscreen Displays, Voice Control Systems, Haptic Feedback Systems, Heads-Up Displays (HUD)
- Power Supply Components: Battery Packs, Power Distribution Units (PDU), Inverters and Converters, Uninterruptible Power Supply (UPS) Systems
- Actuators and Mechanics: Electric Actuators, Hydraulic Actuators, Motors for Steering and Braking, Adaptive Suspension Systems
- Safety Systems: Redundant Systems for Critical Functions, Fail-Safe Mechanisms, Emergency Stop Systems, Collision Avoidance Systems, Crumple Zones and Reinforced Structures
- Navigation and Localization: Global Positioning Systems (GPS), Inertial Measurement Units (IMU), High-Definition Maps (HD Maps), Real-Time Kinematic (RTK) Positioning Systems
- Data Storage and Management: Solid-State Drives (SSDs), Data Loggers, Cloud Storage Solutions, Edge Computing Devices
- Testing and Validation Equipment: Simulation Software, Testing Rigs and Benches, Real-World Testing Environments, Data Annotation Tools
- Interior and Comfort Components: Adjustable Seats with Memory, Climate Control Systems, Interior Lighting, Advanced Audio Systems, Passenger Entertainment Systems
- Exterior Components: Body Panels with Integrated Sensors, Adaptive Headlights, Aerodynamic Elements, Signal and Indicator Lights, Smart Mirrors
- Energy Management Systems: Regenerative Braking Systems, Energy Harvesting Systems, Battery Management Systems (BMS)
- Miscellaneous Components: Tires with Integrated Sensors, Specialized Fasteners, Insulation Materials, Noise Reduction Components

2.2. Critical production technologies

- Sensor Technologies
  - Lidar Sensors
    - Optical Components Manufacturing: Precision optics manufacturing including lenses and mirrors.
    - Sensor Integration: Assembly of laser emitters, detectors, and signal processing electronics.
  - Radar and Ultrasonic Sensors
    - Antenna Design and Manufacturing: High-frequency antenna design and fabrication.
    - Signal Processing Electronics: PCB assembly for radar and ultrasonic signal processing.
  - Camera Systems
    - Lens Manufacturing: Precision lens grinding and polishing.
    - Image Sensor Integration: Mounting and calibration of image sensors onto PCBs.
- Computing and Processing Units
  - Central Processing Units (CPUs)
    - Semiconductor Fabrication: Cleanroom processes like lithography, etching, and doping for CPU chips.
    - Packaging and Testing: Assembling and testing of CPUs into integrated circuits.
  - Graphics Processing Units (GPUs)
    - High-Performance Computing: Manufacturing GPUs for parallel processing tasks.
    - Graphics Card Assembly: Mounting GPUs onto PCBs and heat sink integration.
  - Neural Network Accelerators
    - ASIC (Application-Specific Integrated Circuit) Design: Customized chips optimized for neural network operations.
    - FPGA (Field-Programmable Gate Array) Development: Configurable logic for accelerated computing.
- Control Systems
  - Vehicle Control Units (VCUs)
    - Electronic Control Module (ECM) Production: Manufacturing ECUs for vehicle control and communication.
    - Software Integration: Programming and testing control algorithms.
  - Drive-by-Wire Systems
    - Electronic Actuator Manufacturing: Production of actuators for brake-by-wire and steer-by-wire systems.
    - Sensor Integration: Integration of position sensors and feedback systems.
- Software and Algorithms
  - Sensor Fusion Software
    - Algorithm Development: Software for integrating data from multiple sensors.
    - Machine Learning Models: Training and deployment of AI models for object recognition and decision-making.
  - Path Planning and Navigation Algorithms
    - Algorithm Optimization: Real-time route planning and obstacle avoidance algorithms.
    - Simulations and Testing: Virtual testing environments for algorithm validation.
- Communication Systems
  - Vehicle-to-Vehicle (V2V) Communication
    - Wireless Communication Protocols: Development of protocols for vehicle communication.
    - Antenna Design: Design and testing of antennas for reliable V2V communication.
  - Vehicle-to-Infrastructure (V2I) Communication
    - Network Infrastructure: Development of infrastructure for roadside units.
    - Data Transmission Protocols: Secure protocols for vehicle-to-cloud communication.
- Safety Systems

- Advanced Driver Assistance Systems (ADAS)
  - Sensor Integration: Integration of sensors for adaptive cruise control and lane departure warning systems.
  - Safety-Critical Software Development: Development and validation of software for collision avoidance.
- Collision Detection Systems
  - Sensor Fusion Algorithms: Algorithms for integrating data from lidar, radar, and cameras.
  - Emergency Response Systems: Integration of collision detection with autonomous braking systems.

- Testing and Validation
  - Simulated Environments
    - Virtual Testing Platforms: Simulations of various driving scenarios and environmental conditions.
    - Hardware-in-the-Loop (HIL) Testing: Integration testing of hardware components in simulated environments.
  - Real-World Testing
    - Prototype Testing: Testing autonomous vehicles on closed tracks and public roads.
    - Data Collection and Analysis: Analyzing real-world performance data to refine algorithms.
- Manufacturing and Assembly Technologies
  - Additive Manufacturing (3D Printing)
    - Rapid Prototyping: Quick iteration of design concepts for sensors and enclosures.
    - Customized Component Production: Manufacturing complex parts for prototypes and low-volume production.
  - Robotics and Automation
    - Assembly Line Robotics: Automated assembly of electronic components and subsystems.
    - Quality Control Systems: Automated inspection of sensor accuracy and performance.
- Cybersecurity and Data Privacy
  - Secure Software Development
    - Encryption and Authentication: Secure communication protocols for protecting vehicle data.
    - Intrusion Detection Systems: Monitoring for unauthorized access and potential cyber threats.

2.3. Critical competencies

- Advanced Sensor Technology
  - Lidar Sensors: Expertise in designing and manufacturing high-precision lidar sensors for 3D mapping and object detection.
  - Radar and Ultrasonic Sensors: Expertise in developing sensors for accurate distance measurement and object detection in various weather conditions.
  - Camera Systems: Expertise in designing high-resolution cameras and image processing algorithms for visual recognition and perception.
- Embedded Systems and Electronics
  - Electronic Control Units (ECUs): Design, developing and producing ECUs for real-time processing and control of vehicle functions.
  - Drive-by-Wire Systems: Designing and implementing electronic systems for brake-by-wire and steer-by-wire functionalities.
  - Navigation and Positioning Systems: Integrating GPS, inertial measurement units (IMUs), and other positioning technologies for precise localization.
- Software Development

  - Embedded Software: Developing real-time software for autonomous driving functionalities, including perception, localization, and decision-making.
  - Simulation and Testing: Using simulation tools for testing and validating autonomous driving algorithms and systems.
  - OTA Updates: Implementing over-the-air update capabilities for continuous improvement and maintenance of autonomous systems.
- Artificial Intelligence and Machine Learning
  - Algorithm Development: Creating algorithms for sensor fusion, object recognition, path planning, and decision-making.
  - Machine Learning Models: Expertise in training models for behaviour prediction, anomaly detection, and adaptive control systems.
  - Edge Computing: Implementing AI and machine learning capabilities directly within embedded systems for real-time processing.
  - Deep Learning: Knowledge of deep neural networks and their applications in autonomous driving systems.
- Safety and Functional Safety
  - Functional Safety Standards: Understanding and implementing safety requirements for autonomous vehicle components.
  - Failure Mode and Effects Analysis (FMEA): Ability to conduct risk assessments and implement safety measures to ensure safe autonomous operations.
  - Safety-Critical Design: Designing components with redundancy and fail-safe mechanisms to ensure safe operation.
- Cybersecurity
  - Secure Communication Protocols: Implementing secure communication protocols for vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication.
  - Intrusion Detection Systems: Detecting and mitigating cybersecurity threats to vehicle systems and data.
  - Secure Software Development: Developing secure software and firmware updates to prevent unauthorized access.
- System Integration
  - Integration of Complex Systems: Experience in integrating sensors, ECUs, actuators, and communication systems into a cohesive autonomous driving system.
  - Validation and Verification: Conducting thorough testing and validation to ensure system performance and safety compliance.
  - Hardware-in-the-Loop (HIL) Testing: Utilizing HIL testing for real-world simulation of autonomous vehicle operations.
- Simulation and Testing
  - Virtual Testing Environments: Creating virtual simulations for testing autonomous driving algorithms and systems.
  - Hardware-in-the-Loop (HIL) Testing: Integrating components into simulated environments for real-world scenario testing.
  - Field Testing and Validation: Conducting extensive testing in controlled environments and on public roads to validate system performance.
- Design for Manufacturing (DFM)
  - Optimized Design: Designing components for manufacturability and scalability.
  - Material Selection: Selecting materials that balance performance, durability, and cost-effectiveness.
  - Advanced Manufacturing Techniques: Utilizing additive manufacturing, precision machining, and automation for high-quality production.
- Project Management
  - Project Planning and Execution: Skills in planning, coordinating, and managing projects related to autonomous vehicle component development.

  - Cross-functional Collaboration: Ability to collaborate with teams across engineering, production, quality assurance, and regulatory compliance.
  - Risk Management: Identifying and mitigating risks associated with project timelines, resource allocation, and technical challenges.
- Regulatory Compliance
  - Automotive Standards and Regulations: Ensuring compliance with automotive industry standards and regulations governing autonomous vehicle technologies.
  - Certification Processes: Managing the certification process for autonomous vehicle components and systems.

3. Connectivity

3.1. Products

- Communication Systems: Vehicle-to-Vehicle (V2V) Communication Systems, Vehicle-to-Infrastructure (V2I) Communication Systems, Vehicle-to-Everything (V2X) Communication Systems, Dedicated Short-Range Communication (DSRC) Modules, 5G Connectivity Modules, Telematics Control Units (TCU)
- Data Processing and Storage: Central Processing Units (CPUs), Graphics Processing Units (GPUs), Edge Computing Devices, Cloud Storage Solutions, Onboard Data Storage (SSDs, HDDs), Data Loggers
- Sensors and Actuators: Lidar Sensors, Radar Sensors, Ultrasonic Sensors, Cameras (Front, Rear, Surround View), Environmental Sensors (Temperature, Humidity), Electric Actuators
- Control Systems: Vehicle Control Units (VCU), Electronic Control Units (ECU), Powertrain Control Modules (PCM), Body Control Modules (BCM)
- Human-Machine Interface (HMI): Touchscreen Displays, Digital Instrument Clusters, Voice Recognition Systems, Heads-Up Displays (HUD), Haptic Feedback Systems
- Navigation and Localization: Global Positioning Systems (GPS), Inertial Measurement Units (IMU), Real-Time Kinematic (RTK) Positioning Systems, High-Definition Maps (HD Maps)
- Infotainment Systems: Multimedia Systems, Advanced Audio Systems, Connectivity Ports (USB, HDMI), Wireless Connectivity (Bluetooth, Wi-Fi), Rear-Seat Entertainment Systems
- Security Systems: Cybersecurity Modules, Encryption Hardware and Software, Biometric Authentication Systems, Vehicle Access Control Systems
- Remote Services and Management: Remote Diagnostic Systems, Over-the-Air (OTA) Update Systems, Fleet Management Systems, Remote Lock and Unlock Systems
- Safety Systems: Advanced Driver Assistance Systems (ADAS), Collision Avoidance Systems, Automatic Emergency Braking (AEB), Lane Keeping Assist Systems, Blind Spot Detection Systems
- Energy Management Systems: Battery Management Systems (BMS), Energy Harvesting Systems, Regenerative Braking Systems
- Charging Systems: Smart Charging Ports, Wireless Charging Systems, Home Charging Stations, Public Charging Infrastructure
- Environmental Monitoring: Air Quality Sensors, Weather Monitoring Systems, Tire Pressure Monitoring Systems (TPMS)
- Interior Comfort and Convenience: Climate Control Systems, Adjustable and Heated Seats, Ambient Lighting, Power Windows and Locks, Sunroof and Moonroof Controls
- Exterior Components: Adaptive Headlights, Signal and Indicator Lights, Smart Mirrors, Windshield Wipers with Sensors, Aerodynamic Components
- Software and Applications: Navigation Software, Entertainment Apps, Vehicle Health Monitoring Apps, Mobile Connectivity Apps, Driver Behavior Analysis Software
- Miscellaneous Components: Smart Tires, Insulation Materials, Fasteners and Connectors, Noise Reduction Components

3.2. Services

- Remote Diagnostics and Maintenance: Remote Vehicle Diagnostics, Predictive Maintenance Alerts, Software and Firmware Over-the-Air (OTA) Updates, Remote Vehicle Monitoring, Service Scheduling and Reminders
- Navigation and Traffic Management: Real-Time Traffic Updates, Turn-by-Turn Navigation, Dynamic Route Planning, Integrated Traffic Management Systems, Hazard and Accident Alerts
- Infotainment and Connectivity: Streaming Media Services, In-Car Internet Access, App Integration (Music, Podcasts, News), Social Media Access, Voice-Activated Assistants
- Safety and Security: Emergency Response Services (eCall), Stolen Vehicle Tracking and Recovery, Remote Lock/Unlock, Driver Behaviour Monitoring, Collision Detection and Reporting
- Vehicle-to-Everything (V2X) Communication: Vehicle-to-Vehicle (V2V) Communication, Vehicle-to-Infrastructure (V2I) Communication, Vehicle-to-Pedestrian (V2P) Communication, Vehicle-to-Network (V2N) Communication, Cooperative Adaptive Cruise Control (CACC)
- Fleet Management: Real-Time Fleet Tracking, Fuel Consumption Monitoring, Driver Performance Analysis, Maintenance Scheduling, Route Optimization
- Energy Management: Smart Charging Services, Energy Consumption Monitoring, Battery Health Management, Vehicle-to-Grid (V2G) Services, Renewable Energy Integration
- Insurance and Financial Services: Usage-Based Insurance (UBI), Pay-As-You-Drive (PAYD) Insurance, Claims Management, In-Vehicle Payment Services, Financing and Leasing Management
- Personalization and User Experience: Personalized In-Car Settings (Seats, Climate, Audio), Profile-Based Preferences, Customizable Dashboards, User Behaviour Analysis, Context-Aware Recommendations
- Data Services and Analytics: Telematics Data Collection, Big Data Analytics, Cloud-Based Data Storage, Driver Analytics and Reports, Vehicle Health Reports
- Autonomous Driving Support: High-Definition Map Updates, Remote Assistance for Autonomous Vehicles, Fleet Coordination for Autonomous Vehicles, Autonomous Driving Performance Monitoring, Safe Zone Identification
- Environmental Monitoring: Real-Time Weather Updates, Air Quality Monitoring, Environmental Hazard Alerts, Eco-Driving Assistance, Emissions Monitoring
- Retail and Commerce: In-Vehicle Shopping and Delivery Services, Location-Based Offers and Discounts, Digital Advertising, Parking Reservations and Payments, Fuel and Charging Station Locators
- Mobility Services: Ride-Hailing and Ride-Sharing Integration, Car Sharing Services, Public Transportation Integration, Multi-Modal Trip Planning, Micro-Mobility Services (eScooters, Bikes)
- Advanced Driver Assistance Systems (ADAS): Lane Keeping Assistance, Adaptive Cruise Control, Automatic Emergency Braking, Blind Spot Detection, Parking Assistance
- User Training and Support: Driver Education and Training Programs, Customer Support Services, In-App Tutorials and Guidance, Virtual Assistance
- Regulatory Compliance and Reporting: Regulatory Compliance Monitoring, Automated Reporting Services, Compliance with Emissions Standards, Safety Standards Adherence

3.3. Critical production technologies

- Communication Systems
    - Wireless Connectivity Modules
        - RF (Radio Frequency) Technology: Design and production of antennas and RF circuits.
        - Bluetooth, Wi-Fi, Cellular (5G, LTE): Integration of wireless communication standards.
    - Telematics Control Units (TCUs)
        - Embedded Systems Development: Software and hardware integration for vehicle connectivity.
        - SIM Card Integration: Provisioning and management of SIM cards for cellular connectivity.
- Data Processing and Storage

- Central Processing Units (CPUs)
  - High-Performance Computing: Development and manufacturing of processors for onboard data processing.
  - AI and Machine Learning Accelerators: Hardware for real-time data analytics and decision-making.
- Storage Solutions
  - Solid-State Drives (SSDs): High-speed data storage for vehicle telemetry and media.
  - Embedded Flash Memory: Storage solutions for firmware and software updates.

- Sensors and Actuators
  - Environmental Sensors
    - Temperature, Humidity Sensors: Manufacturing of sensors for climate control and cabin comfort.
    - Gas Sensors: Detection of pollutants and air quality monitoring.
  - Positioning and Navigation Systems
    - Global Navigation Satellite Systems (GNSS): Integration of GPS, Galileo, and other positioning technologies.
    - Inertial Measurement Units (IMUs): Sensors for vehicle orientation and movement.
- Control Systems
  - Electronic Control Units (ECUs)
    - Powertrain Control Modules (PCMs): Control units for electric and hybrid vehicle propulsion systems.
    - Body Control Modules (BCMs): Integration of electronic systems for vehicle functions.
  - Vehicle-to-Everything (V2X) Communication
    - Dedicated Short-Range Communication (DSRC): Technologies for vehicle-to-vehicle and vehicle-to-infrastructure communication.
    - 5G Connectivity: Infrastructure and hardware for high-speed cellular communication.
- Infotainment Systems
  - Multimedia Interfaces
    - Touchscreen Displays: Manufacturing of high-resolution displays for user interfaces.
    - Audio Systems: Integration of speakers and amplifiers for in-car entertainment.
  - Connectivity Ports
    - USB, HDMI Ports: Integration of ports for connecting external devices and media.
- Security Systems
  - Cybersecurity Modules
    - Secure Boot and Authentication: Hardware and software solutions for protecting vehicle data and systems.
    - Encryption Technologies: Data encryption techniques for secure communication channels.
  - Vehicle Access Control
    - Keyless Entry Systems: Integration of smart key systems and biometric authentication.
    - Remote Lock/Unlock Features: Connectivity solutions for remote vehicle access.
- Remote Services and Management
  - Over-the-Air (OTA) Updates
    - OTA Software Platforms: Infrastructure for remotely updating vehicle software and firmware.
    - Fleet Management Systems: Tools for monitoring and managing connected vehicle fleets.
  - Remote Diagnostics
    - Telematics Solutions: Data collection and analysis for proactive vehicle maintenance.
    - Remote Monitoring Systems: Real-time monitoring of vehicle health and performance.
- Safety Systems
  - Advanced Driver Assistance Systems (ADAS)
    - Collision Avoidance Systems: Sensors and algorithms for detecting and mitigating collision risks.

        - Lane Keeping Assist Systems: Technologies for assisting drivers in maintaining lane position.
    - Emergency Services
        - Automatic Emergency Braking (AEB): Systems for automatically applying brakes in emergency situations.
        - Emergency Call (eCall) Systems: Integration with emergency services for rapid response.
- Energy Management Systems
    - Battery Management Systems (BMS)
        - Battery Monitoring and Control: Hardware and software for managing battery performance and safety.
        - Charging Infrastructure: Solutions for managing electric vehicle charging networks.
- Environmental Monitoring
    - Air Quality Sensors
        - Pollution Detection: Sensors for monitoring air quality inside and outside the vehicle.
        - Weather Sensors: Integration of sensors for monitoring weather conditions.
- Software and Applications
    - Navigation Software
        - Map Data Integration: Technologies for integrating and updating high-definition map data.
        - Real-Time Traffic Information: Systems for providing drivers with up-to-date traffic conditions.
    - Entertainment Apps
        - Streaming Services Integration: Integration of streaming media services for in-car entertainment.
        - Smartphone Integration: Connectivity solutions for seamless integration with mobile devices.
- User Experience and Interface
    - Human-Machine Interface (HMI)
        - Voice Recognition Systems: Integration of voice-activated commands for hands-free operation.
        - Gesture Control: Technologies for controlling vehicle functions through gestures.
    - Personalization
        - Driver Profiles: Customizable settings for multiple drivers.
        - Context-Aware Systems: Adaptive systems that adjust based on driver preferences and conditions.

3.4. Main competencies

- Technical Expertise
    - Electronics Engineering: Understanding of electronics principles and circuits relevant to connected car components.
    - Software Development: Proficiency in embedded software development for ECUs, connectivity modules, and IoT devices.
    - Wireless Communication: Knowledge of RF technologies, Bluetooth, Wi-Fi, and cellular networks used in automotive applications.
    - Sensor Integration: Skills in integrating sensors for environmental monitoring, vehicle diagnostics, and advanced driver assistance systems (ADAS).
- Wireless Connectivity
    - RF (Radio Frequency) Technologies: Designing and manufacturing antennas, RF modules, and wireless communication components.
    - Bluetooth, Wi-Fi, Cellular (5G, LTE): Integration of wireless communication standards for vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication.

    - Telematics Control Units (TCUs): Developing hardware and software for integrated connectivity solutions.
- Embedded Systems and Electronics
    - Electronic Control Units (ECUs): Designing ECUs for managing connected vehicle systems and data.
    - Microcontrollers and Processors: Integration of processors capable of handling real-time data processing and communications.
    - Sensor Integration: Incorporating sensors for environmental monitoring and vehicle diagnostics.
- System Integration
    - Embedded Systems Integration: Experience in integrating hardware and software components into embedded systems for seamless operation.
    - Cloud Integration: Familiarity with cloud computing platforms and APIs for data storage, processing, and remote access.
    - OTA Updates: Skills in implementing over-the-air (OTA) update mechanisms for software and firmware updates in connected vehicles.
- Data Processing and Analytics
    - Big Data Analytics: Developing capabilities for processing and analyzing large volumes of vehicle data.
    - Cloud Computing: Implementing cloud-based solutions for data storage, processing, and remote access.
    - Edge Computing: Deploying computing capabilities at the edge for real-time data processing and decision-making.
- Cybersecurity
    - Secure Communication Protocols: Implementing protocols to secure vehicle-to-cloud and vehicle-to-vehicle communications.
    - Intrusion Detection Systems: Detecting and mitigating cybersecurity threats targeting connected car systems.
    - Data Encryption: Encrypting data to protect against unauthorized access and data breaches.
    - Network Security: Understanding of cybersecurity principles and protocols for securing vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications.
    - Data Privacy: Knowledge of data encryption methods and regulations (e.g., GDPR, CCPA) related to connected car data privacy.
    - Threat Detection and Response: Ability to identify and mitigate cybersecurity threats targeting connected car systems.
- Software Development
    - Embedded Software: Developing firmware and software for connected car functionalities.
    - OTA (Over-the-Air) Updates: Implementing solutions for remote software updates and patches.
    - Mobile Apps Integration: Integrating mobile applications for remote vehicle monitoring and control.
- User Interface and Experience
    - Human-Machine Interface (HMI): Designing intuitive interfaces for driver interaction with connected car features.
    - Voice Recognition: Integrating voice-activated controls for hands-free operation.
    - Integration with Infotainment Systems: Connecting vehicle systems with multimedia and entertainment features.
- Regulatory Compliance
    - Automotive Standards: Ensuring compliance with automotive regulations and standards related to connectivity and data privacy. Knowledge of regulatory requirements and standards relevant to automotive electronics and connectivity.
    - Industry Certifications: Obtaining certifications for quality management systems and cybersecurity protocols.
- Environmental Sustainability

  - Green Manufacturing Practices: Implementing sustainable manufacturing processes and reducing environmental impact.
  - Lifecycle Assessment: Analysing environmental impacts throughout the product lifecycle and implementing recycling and disposal strategies.
- Project Management
  - Project Planning: Skills in planning and coordinating tasks, resources, and timelines for component development projects.
  - Risk Management: Ability to assess and mitigate risks associated with project execution and product delivery.
  - Cross-functional Collaboration: Experience in collaborating with teams across engineering, production, sales, and customer support functions.

4. Platform economy

4.1. Products

- In-Vehicle Services: GPS Navigation Systems, In-Car Wi-Fi, Infotainment Systems, Child Safety Seats, Roadside Assistance
- Convenience Products: Keyless Entry Systems, Mobile App Access, Contactless Payment Options, Real-Time Vehicle Tracking, On-Demand Vehicle Delivery
- Maintenance and Care Packages: Cleaning Services, Vehicle Sanitization Services, Tire Replacement and Rotation, Battery Maintenance for EVs
- Eco-Friendly Options: Green Driving Incentives, Eco-Driving Training
- Mobility Services: Ride-Hailing Integration, Carpooling Options, Multi-Modal Transportation Integration, First-Mile/Last-Mile Solutions, Public Transport Integration
- Safety and Security Products: Advanced Driver Assistance Systems (ADAS), Vehicle Tracking and Recovery Systems, Emergency Assistance Buttons, Driver Safety Training Programs, In-Car Surveillance Cameras
- Technology and Connectivity Solutions: Mobile Booking Apps, In-App Payment Systems, Telematics Solutions, Vehicle Health Monitoring Systems, User-Friendly Booking Portals

4.2. Services

- Vehicle Sharing Services: Peer-to-Peer Car Sharing, Business Fleet Sharing, On-Demand Vehicle Rentals, Long-Term Vehicle Leasing, Subscription-Based Vehicle Access
- Ride-Hailing and Ride-Sharing: On-Demand Ride-Hailing, Carpooling and Ride-Sharing, Luxury Ride Services, Airport Transfers, Event Transportation
- Delivery and Logistics: Last-Mile Delivery Services, Parcel and Package Delivery, Grocery Delivery, Courier Services, Freight and Cargo Transportation
- Vehicle Maintenance and Care: On-Demand Maintenance and Repairs, Mobile Mechanic Services, Vehicle Cleaning and Detailing, Tire Change and Rotation, Battery Replacement and Charging for EVs
- Charging and Fuelling Solutions: EV Charging Network Access, Mobile Fuel Delivery, Subscription Plans for Charging, Energy Management Services, Fuel Card Services
- Telematics and Data Services: Vehicle Tracking and Monitoring, Fleet Management Solutions, Driver Behaviour Analysis, Predictive Maintenance Alerts, Telematics Data Analytics
- Mobility as a Service (MaaS): Integrated Multi-Modal Transportation, Trip Planning and Navigation, Mobility Subscription Packages, Public Transport Integration, Bike and Scooter Rentals
- User Experience and Personalization: Personalized Vehicle Preferences, Customizable Rental Packages, User Profiles and History Tracking, Rewards and Loyalty Programs, User Feedback and Ratings
- Security and Compliance: Background Checks for Drivers, Vehicle Safety Inspections, Regulatory Compliance Services, Fraud Detection and Prevention, Data Privacy and Security Solutions

- Software and App Development: Custom Mobile App Development, Platform Integration Services, User Interface and Experience Design, API Management, Backend Infrastructure Support
- Data and Analytics: Usage Data Collection, Market Analysis and Insights, Customer Behaviour Analysis, Performance Metrics and Reporting, Predictive Analytics for Demand Forecasting

4.3. Critical production technologies

- Fleet Management Systems
  - Vehicle Tracking and Telematics: Utilizing GPS and telematics systems to track vehicle location, performance metrics, and maintenance schedules.
  - Remote Diagnostics: Implementing systems for remote monitoring and diagnostics to ensure vehicle health and efficiency.
  - Predictive Maintenance: Using data analytics to predict and schedule maintenance to minimize downtime.
- Vehicle Connectivity and IoT
  - Connected Vehicle Technologies: Integrating IoT devices and connectivity solutions for real-time communication between vehicles, users, and the central platform.
  - Vehicle-to-Infrastructure (V2I) Communication: Enabling vehicles to interact with smart infrastructure for traffic management, parking guidance, and energy optimization.
  - Data Analytics and Insights: Analyzing vehicle usage data to optimize fleet operations, improve efficiency, and enhance customer experience.
- Mobile Apps and User Interfaces
  - Customer Mobile Applications: Developing intuitive mobile apps for users to book, unlock, and manage vehicle rentals or rides.
  - Driver Applications: Providing apps for drivers to manage their schedules, navigate routes, and communicate with passengers.
  - User Experience Design: Designing user-friendly interfaces for seamless interaction with the platform and vehicles.
- Vehicle Sharing Technologies
  - Keyless Entry Systems: Implementing digital key solutions for secure access to vehicles without physical keys.
  - Vehicle Reservation Systems: Developing systems for users to reserve vehicles in advance through mobile apps or web platforms.
  - Payment Integration: Integrating secure payment gateways for seamless transaction processing for rentals or rides.
- Autonomous and Electric Vehicles (EVs) Integration
  - Autonomous Vehicle Deployment: Developing capabilities to integrate autonomous vehicles into the platform for on-demand transportation.
  - Electric Vehicle Charging Infrastructure: Establishing charging stations and infrastructure to support electric vehicles in the fleet.
  - Battery Management Systems: Implementing systems to monitor and manage battery health and charging schedules for electric vehicles.
- Supply Chain Management
  - Vehicle Procurement and Fleet Acquisition: Managing the procurement of vehicles suitable for shared mobility services, including negotiation with manufacturers or dealers.
  - Inventory Management: Optimizing vehicle inventory to meet fluctuating demand and ensure fleet availability.
  - Logistics and Distribution: Efficiently managing vehicle distribution and relocation within the service area to meet user demand.
- Safety and Compliance

  - Vehicle Safety Standards: Ensuring vehicles meet regulatory safety standards (e.g., crash tests, emissions standards) for passenger safety.
  - Insurance and Liability Management: Addressing insurance requirements and liability issues associated with vehicle sharing and autonomous operations.
  - Compliance with Local Regulations: Adhering to local laws and regulations governing vehicle sharing, autonomous driving, and data privacy.
- Data Security and Privacy
  - Data Encryption and Protection: Implementing robust cybersecurity measures to protect user data, transaction records, and vehicle operation data.
  - Privacy Policies and Compliance: Ensuring compliance with data privacy regulations (e.g., GDPR, CCPA) and transparent data handling practices.
- Customer Support and Service
  - 24/7 Support Services: Providing round-the-clock customer support for users and drivers, including troubleshooting, emergency assistance, and feedback management.
  - Maintenance and Cleaning Services: Establishing protocols for vehicle maintenance, cleaning, and sanitization to ensure a pleasant and safe user experience.
- Environmental Sustainability
  - Green Fleet Initiatives: Implementing strategies to reduce carbon emissions and promote sustainable mobility solutions.
  - Energy Efficiency: Optimizing vehicle operations and route planning to minimize energy consumption and environmental impact.
- Business Analytics and Performance Monitoring
  - Performance Metrics: Tracking and analyzing key performance indicators (KPIs) such as vehicle utilization rates, customer satisfaction scores, and revenue streams.
  - Market Insights: Utilizing data analytics to identify market trends, user behavior patterns, and opportunities for service expansion or optimization.

4.4. Critical competencies

- Technical and Operational Competencies
  - Fleet Management: Ability to oversee and manage vehicle fleets, including maintenance scheduling, logistics, and fleet optimization.
  - Vehicle Technology: Understanding of vehicle technologies, including electric vehicles (EVs), autonomous driving features, and connectivity solutions.
  - Data Analysis: Proficiency in analyzing operational data to optimize vehicle deployment, pricing strategies, and user experience.
  - Mobile and Web Platform Management: Skills in managing mobile apps, web platforms, and backend systems for seamless customer interactions and service delivery.
  - IoT and Connectivity: Knowledge of IoT devices and connectivity solutions to support vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications.
- Customer Service and Communication
  - Customer Relationship Management: Ability to build and maintain positive relationships with customers, addressing inquiries, complaints, and feedback promptly.
  - Effective Communication: Clear and concise communication skills, both verbal and written, for interacting with customers, drivers, and internal teams.
  - Conflict Resolution: Capability to resolve conflicts and handle challenging situations with diplomacy and professionalism.
  - Cultural Sensitivity: Awareness of cultural differences and considerations when interacting with a diverse customer base.
- Business Acumen and Strategic Thinking
  - Market Understanding: Awareness of market trends, competitor analysis, and industry dynamics in the mobility and transportation sectors.

  - Business Development: Skills in identifying growth opportunities, negotiating partnerships, and expanding service offerings.
  - Financial Management: Understanding of budgeting, cost control, and financial metrics to ensure profitability and sustainable growth.
  - Risk Management: Ability to assess risks and implement mitigation strategies related to operations, safety, and regulatory compliance.
- Regulatory Compliance and Safety
  - Regulatory Knowledge: Understanding of local, national, and international regulations governing transportation, data privacy, and vehicle operations.
  - Safety Protocols: Adherence to safety standards and protocols to ensure the well-being of customers, drivers, and the community.
  - Insurance Management: Knowledge of insurance requirements and protocols related to vehicle operations and liability management.
- Problem-Solving and Adaptability
  - Critical Thinking: Ability to analyze complex situations, identify root causes, and develop effective solutions.
  - Adaptability: Readiness to adapt to changes in technology, market conditions, and customer preferences.
  - Decision-Making: Capacity to make informed decisions quickly, considering multiple factors and stakeholders' interests.
- Teamwork and Collaboration
  - Cross-functional Collaboration: Working effectively with colleagues from diverse backgrounds, including operations, technology, marketing, and finance.
  - Leadership and Motivation: Inspiring and leading teams to achieve goals, fostering a collaborative and supportive work environment.
  - Project Management: Skills in planning, organizing, and executing projects, ensuring alignment with organizational objectives and timelines.
- Technology Adoption and Innovation
  - Continuous Learning: Commitment to staying updated with advancements in vehicle technology, mobility solutions, and digital platforms.
  - Innovation: Ability to innovate and implement new ideas to enhance service offerings, improve efficiency, and drive business growth.
  - User Experience (UX) Design: Understanding of UX principles to enhance customer interactions with mobile apps and digital platforms.
- Environmental and Social Responsibility
  - Sustainability Practices: Incorporating sustainable practices in operations, such as promoting electric vehicles, reducing carbon footprint, and supporting eco-friendly initiatives.
  - Community Engagement: Engaging with local communities, stakeholders, and policymakers to promote responsible and inclusive mobility solutions.